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(12) **United States Patent**
Dijkstra et al.

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(45) **Date of Patent: Sep. 19, 2023**

(54) **CAPSULE, A SYSTEM FOR PREPARING A POTABLE BEVERAGE FROM SUCH A CAPSULE AND USE OF SUCH A CAPSULE IN A BEVERAGE PREPARATION DEVICE**

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(51) **Int. Cl.**

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A47J 31/40	(2006.01)

(52) **U.S. Cl.**
CPC ***B65D 85/8046*** (2013.01); ***A47J 31/369*** (2013.01); ***A47J 31/3623*** (2013.01); ***A47J 31/407*** (2013.01); ***B65D 85/8043*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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(57) **ABSTRACT**

A capsule containing a substance for the preparation of a beverage has an aluminum capsule body and a cover sheet hermetically closing off the capsule. The capsule body has a flange with a deformable sealing ring portion with an inner wall portion extending from and contiguous with an inner base portion of the flange, an outer wall portion extending from and contiguous with an outer base portion of the flange and a bridge portion interconnecting the inner wall portion and the outer wall portion. The bridge portion is located axially spaced from the base portions of the flange. In radial

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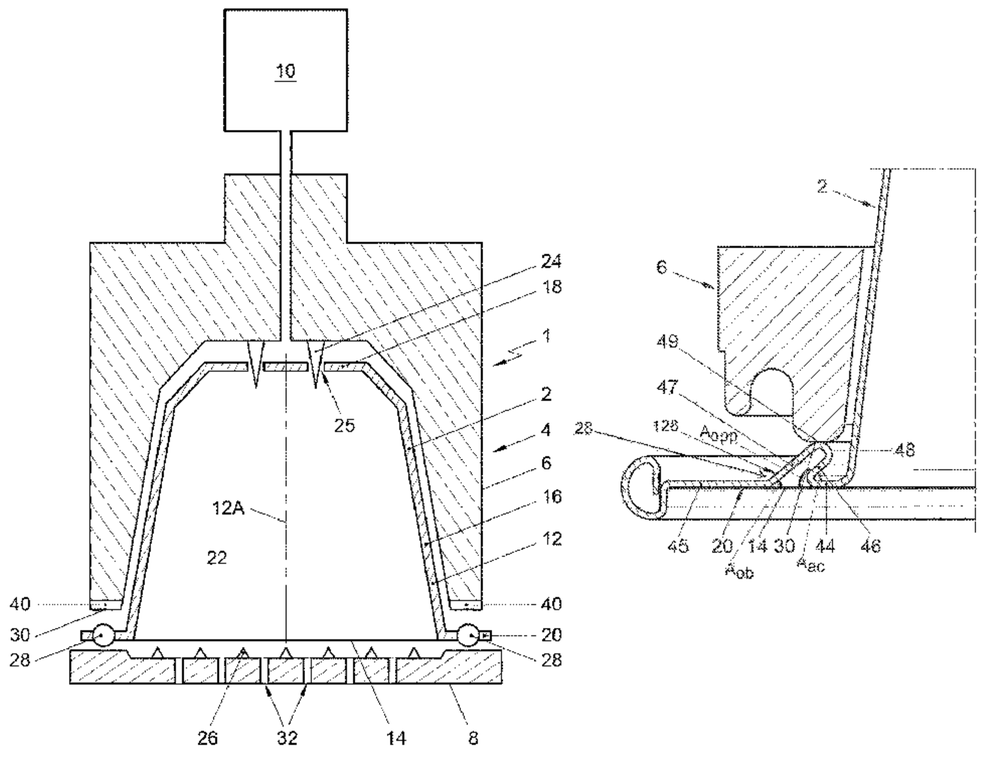

cross-sectional view, a top of the bridge portion axially most remote from the base portions of the flange is flat or has a center plane curved with a radius of curvature larger than two times a wall thickness of the top of the bridge portion.

32 Claims, 8 Drawing Sheets

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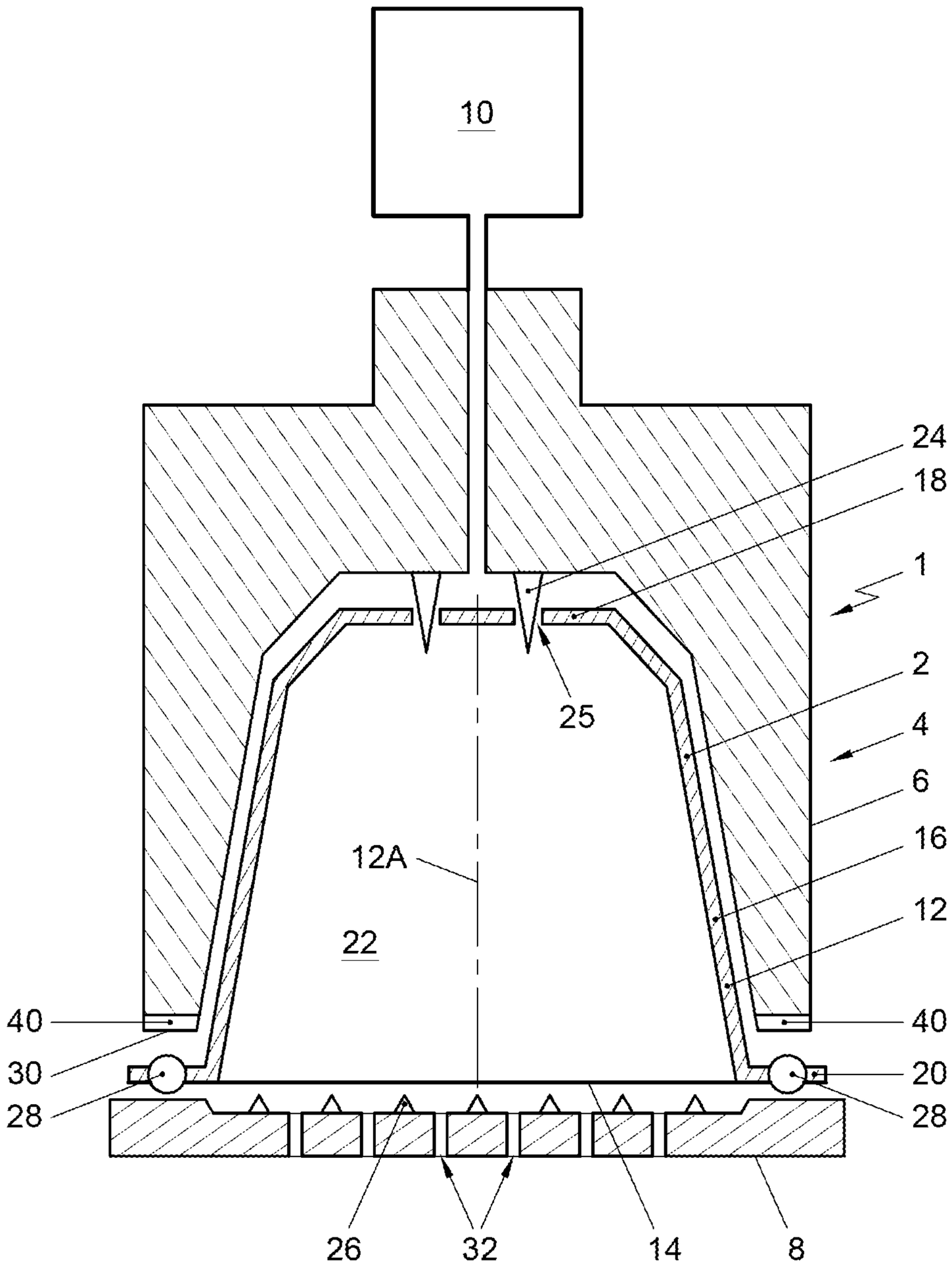

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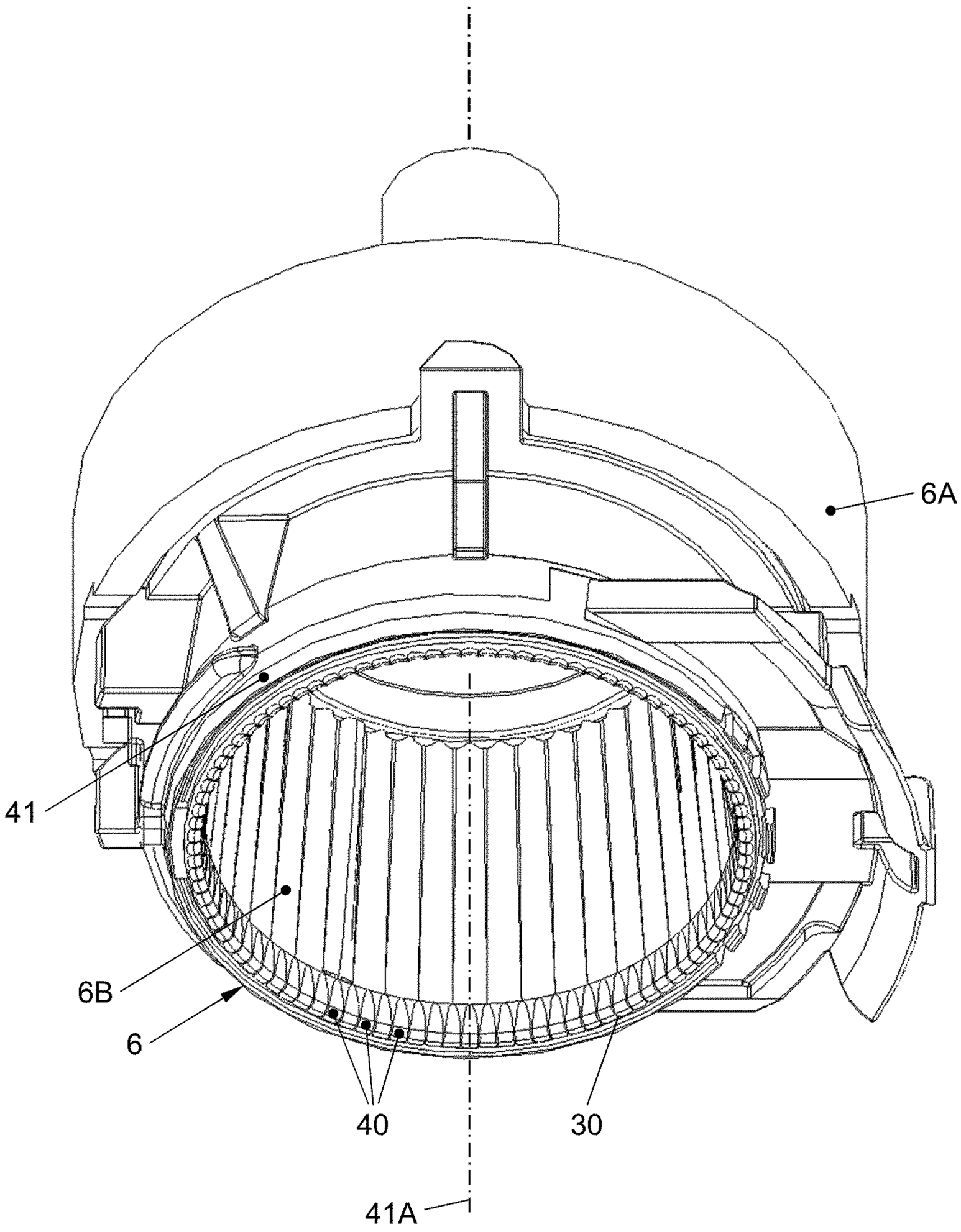

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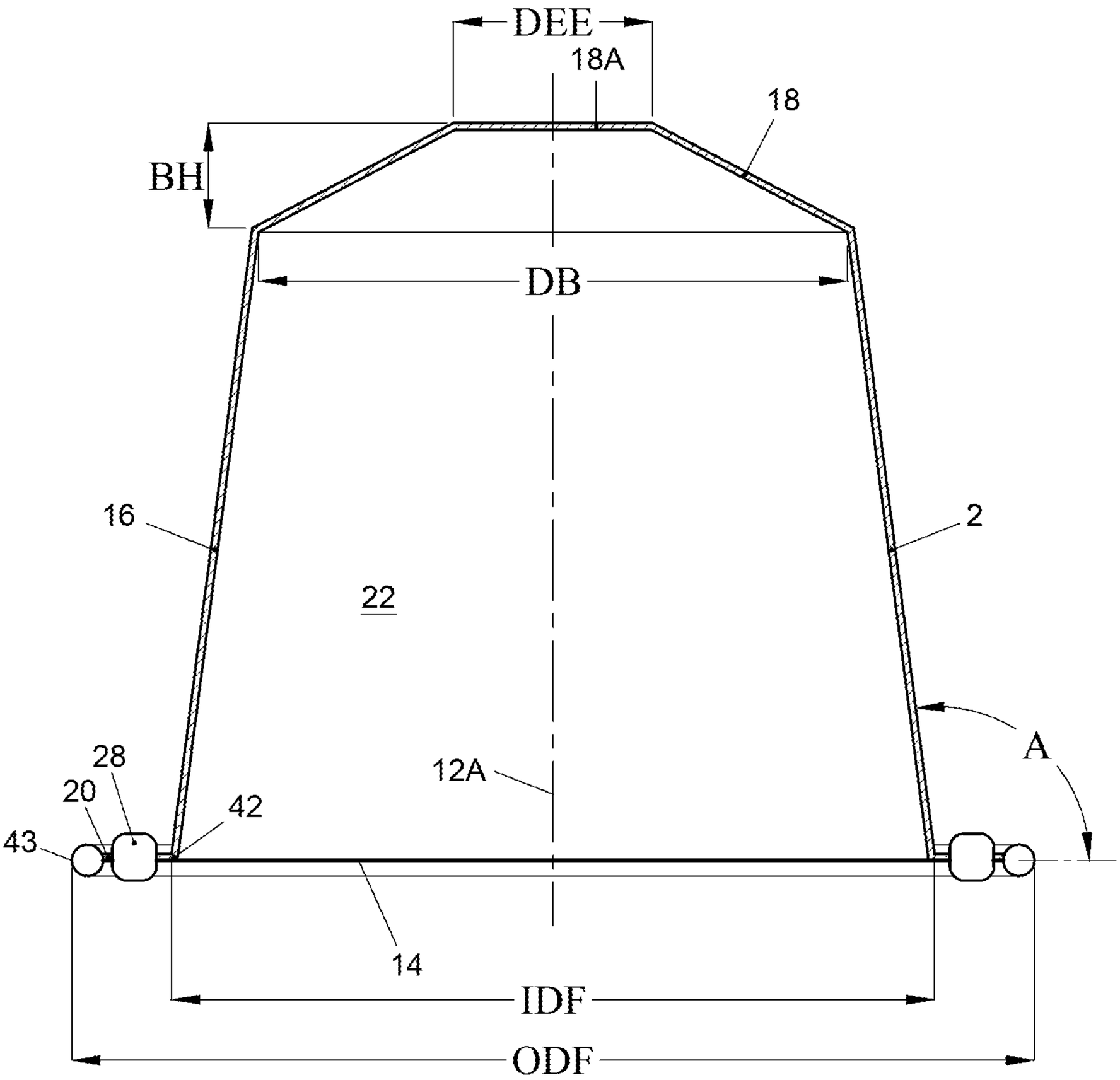
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Fig. 3A

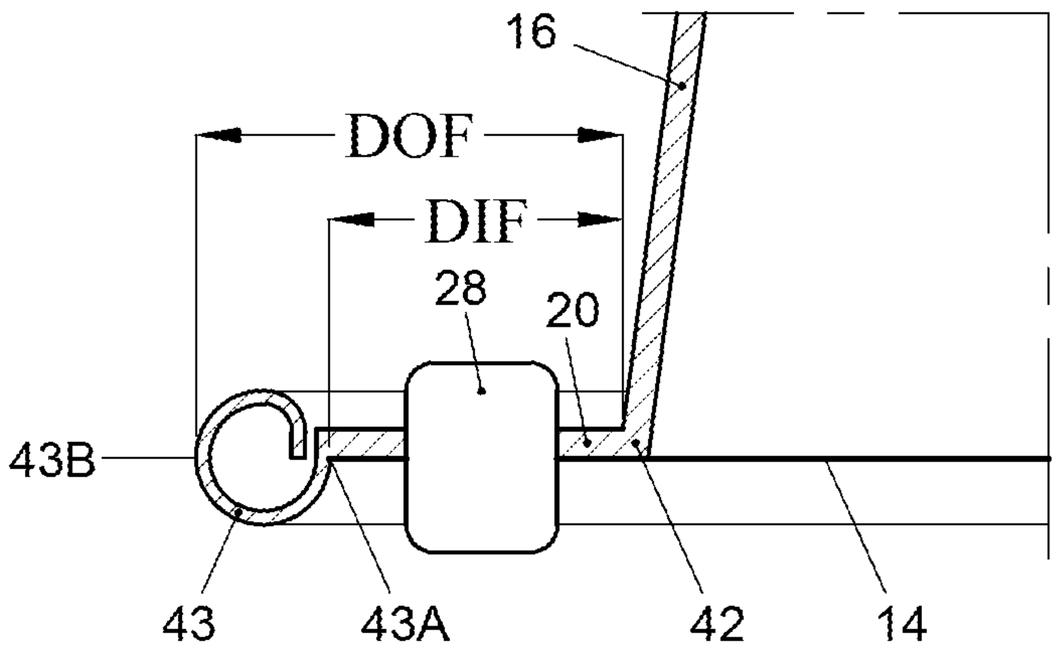
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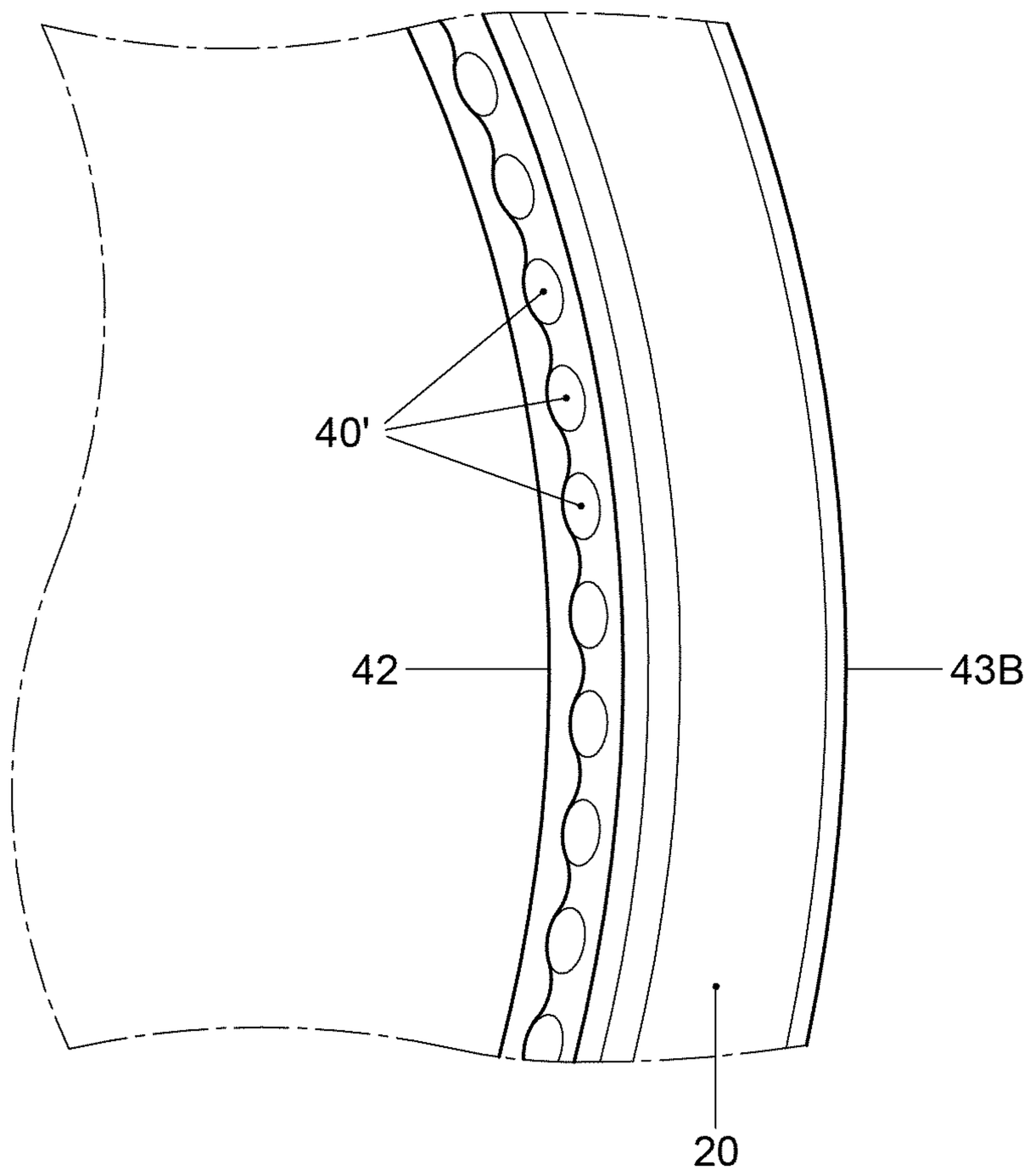
Fig. 3B



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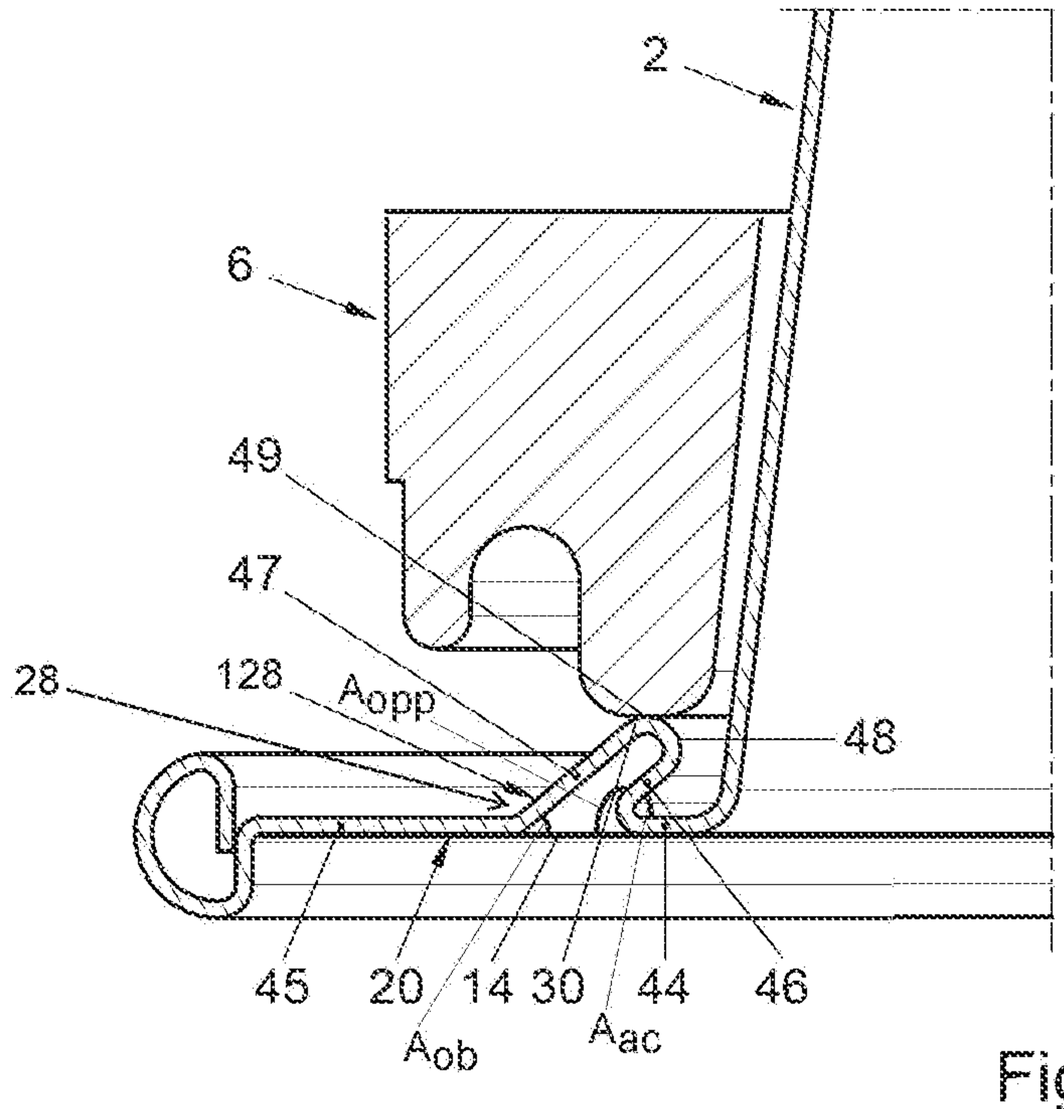
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Fig. 4A

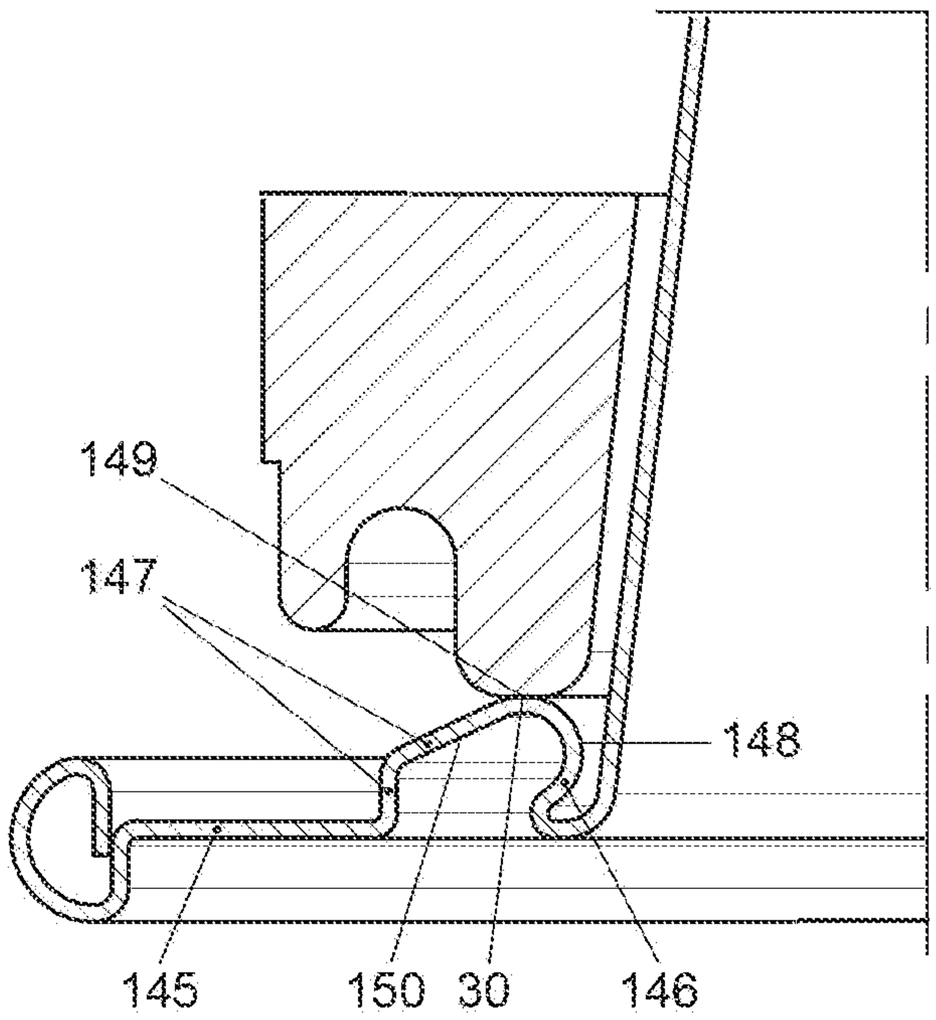
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Fig. 4B

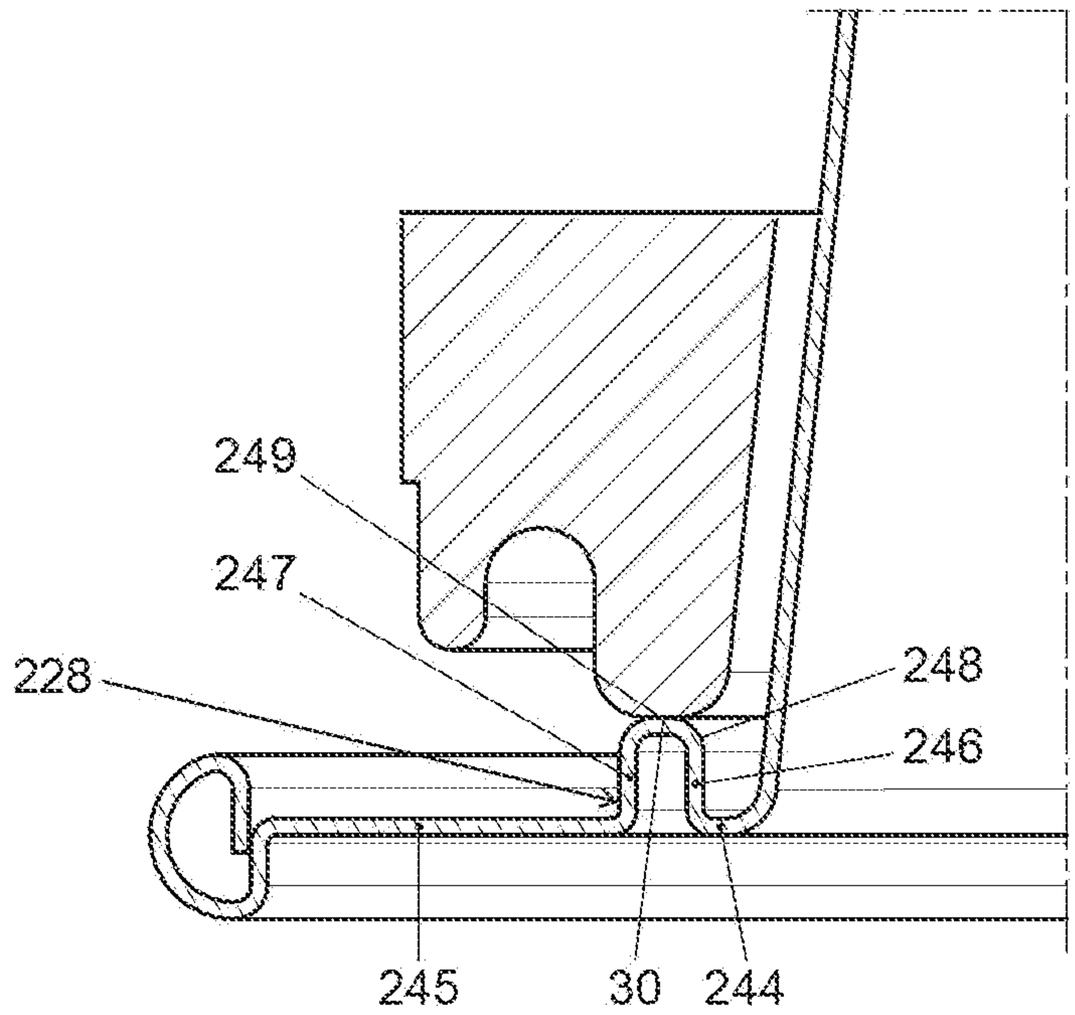

Fig. 4C

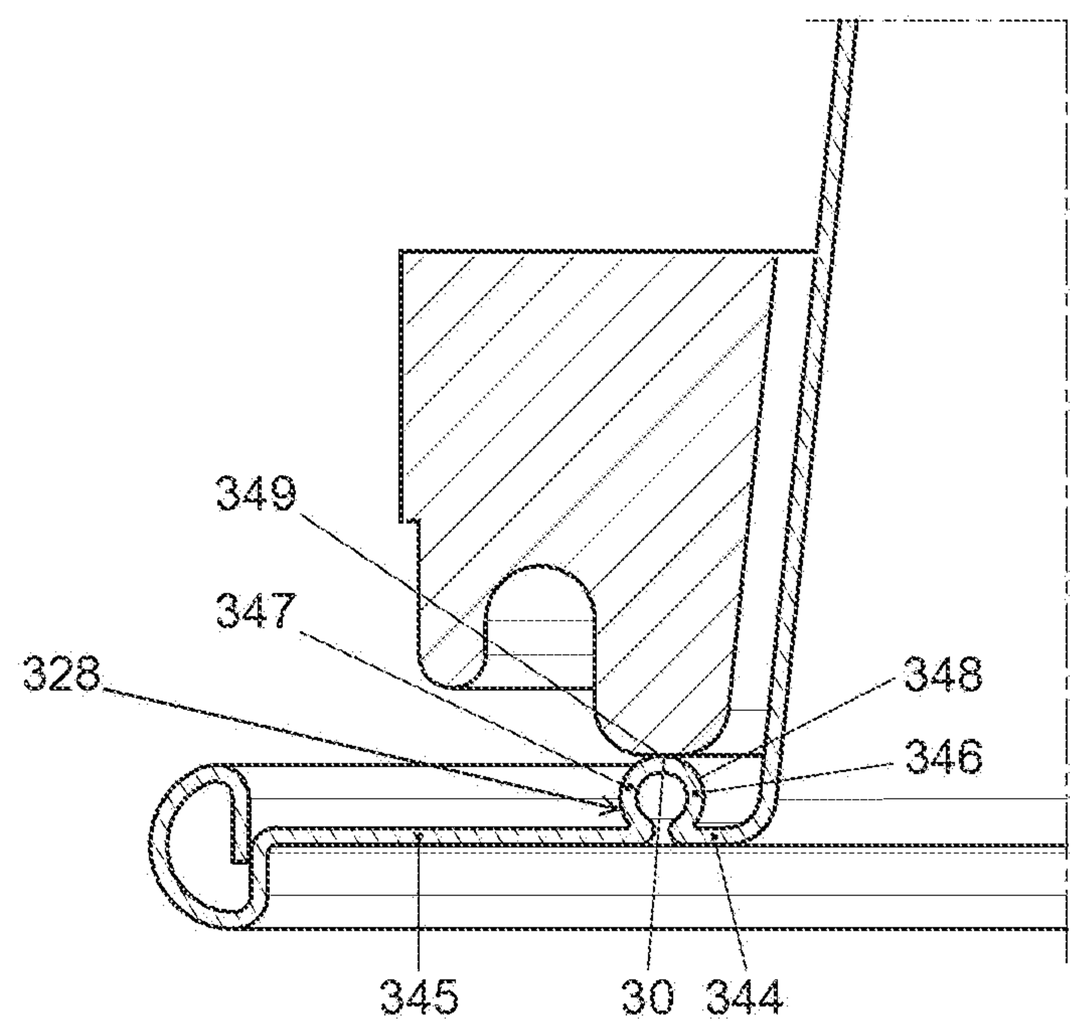

Fig. 4D

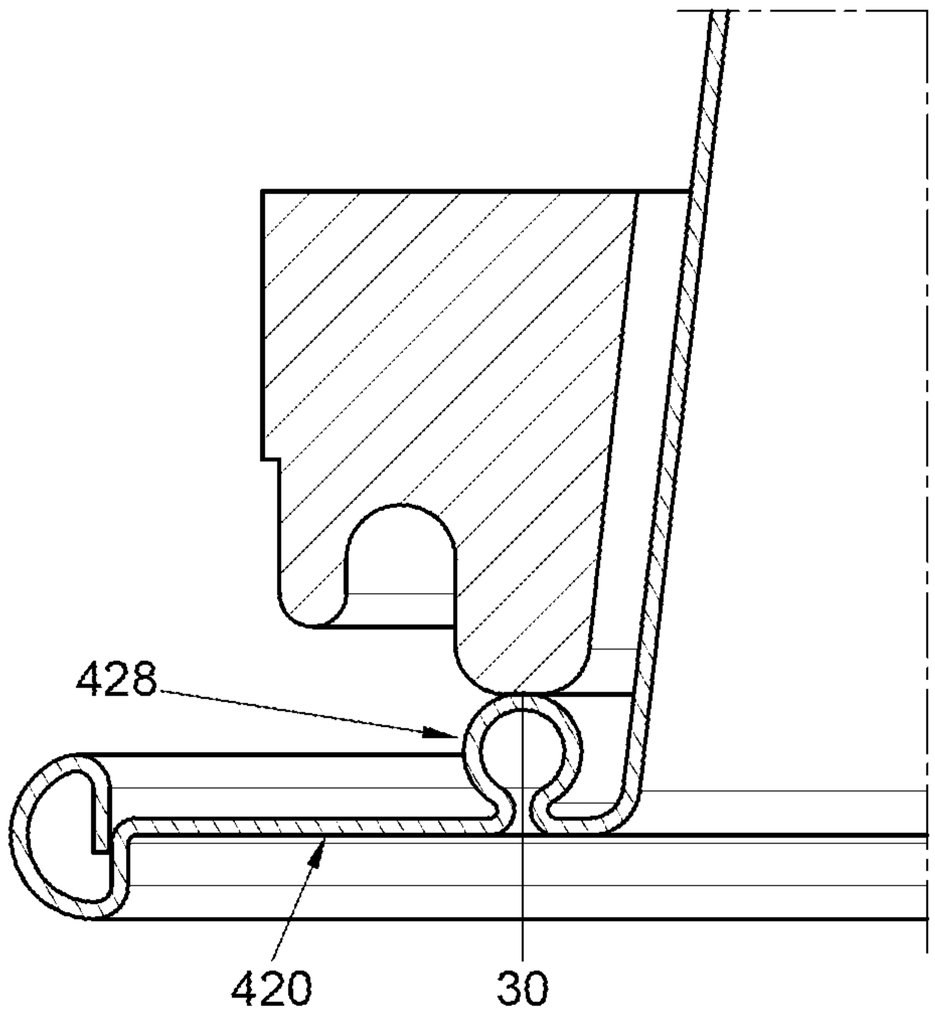

Fig. 4E

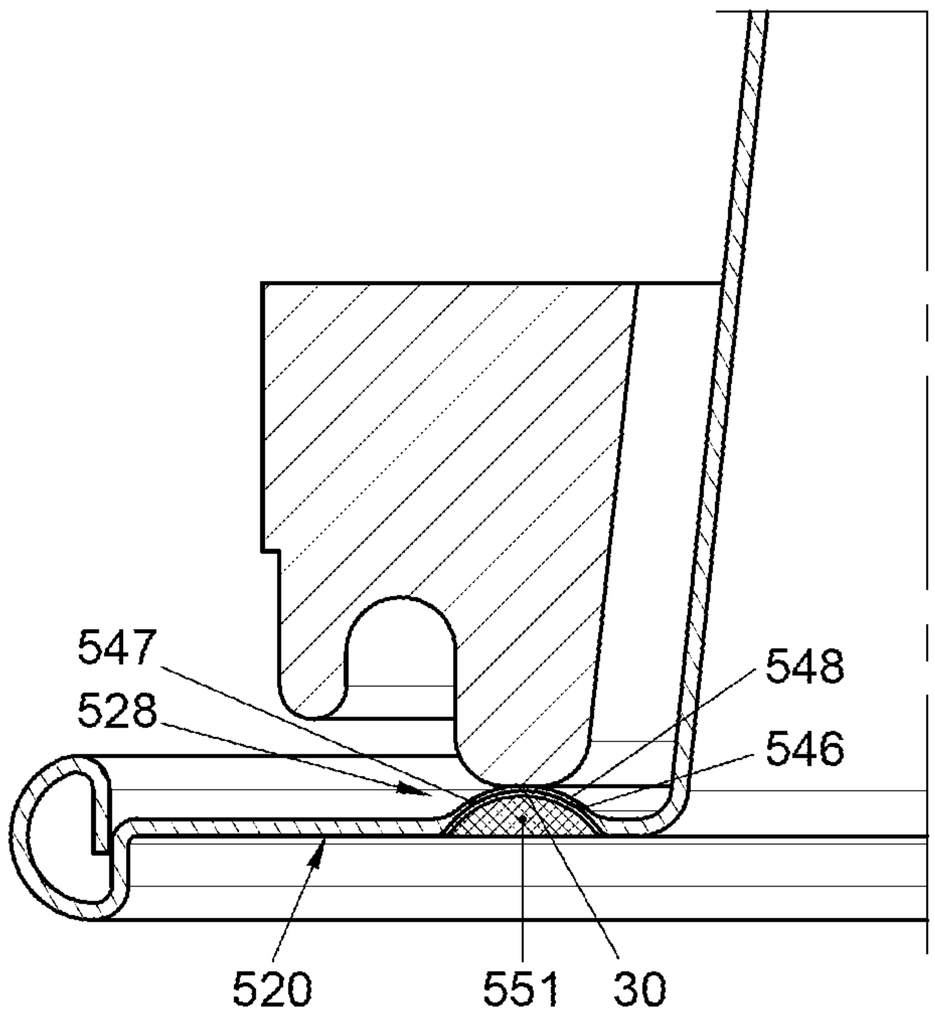

Fig. 4F

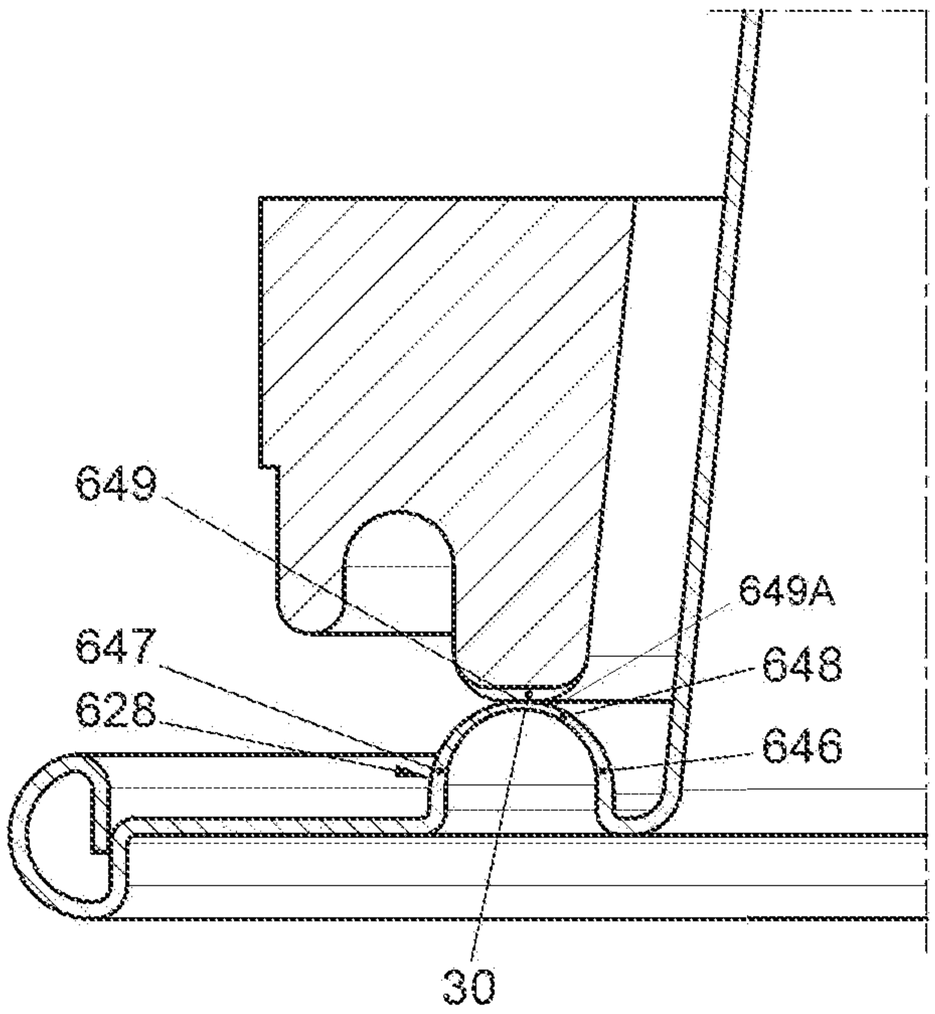

Fig. 4G

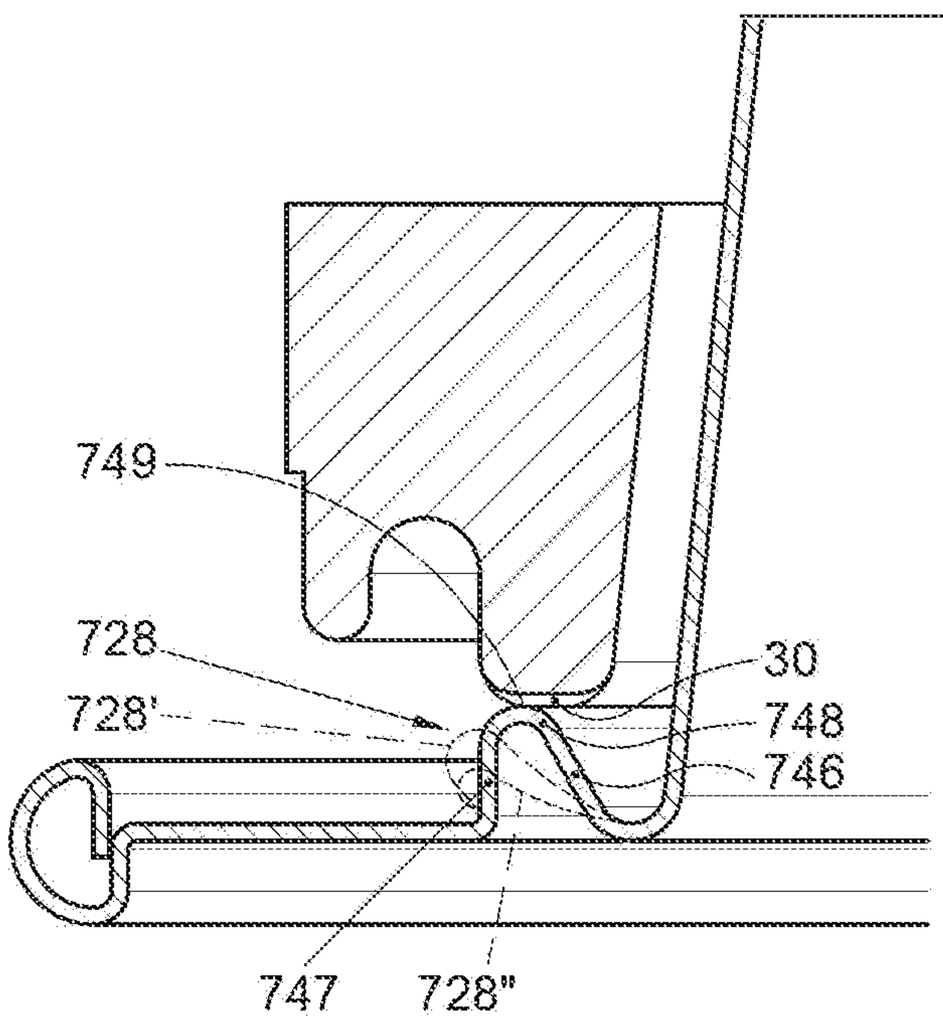

Fig. 4H

CAPSULE, A SYSTEM FOR PREPARING A POTABLE BEVERAGE FROM SUCH A CAPSULE AND USE OF SUCH A CAPSULE IN A BEVERAGE PREPARATION DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of International Application Number PCT/NL2016/050341 filed May 13, 2016, which claims the benefit of and priority to International Application Number PCT/NL2015/050351 15 filed May 15, 2015. The entire contents of all of which are hereby incorporated herein by reference.

BACKGROUND

The invention relates to a capsule containing a substance for the preparation of a potable beverage by extracting and/or dissolving the substance by means of supplying a fluid under pressure into the capsule.

The invention also relates to a system for preparing a potable beverage from a capsule using a fluid supplied under pressure into the capsule and to a use of such a capsule.

Such a capsule, such a system and such a use are known from EP-B-1 700 548, which discloses a capsule provided with a sealing structure having the shape of a step, i.e. a sudden increase of the diameter of the side wall of the capsule, and the enclosing member of this known system has a sealing surface acting on the sealing structure to provide deflection of the sealing structure, the sealing surface being inclined so that the deflection of the sealing structure is an inwards and downwards deformation of the step. Furthermore in the known system the enclosing member comprises a capsule holder and a manually operated or an automatic mechanism for relative displacement of the enclosing member and the capsule holder. The manually operated or automatic mechanism applies a force on the sealing structure of the capsule when the enclosing member closes on the capsule holder. This force should ensure the fluid tight seal between the enclosing member and the capsule. Because the manually operated or automatic mechanism is arranged to be moved relative to the base, the sealing capabilities of the system can depend on the pressure of the fluid injected by the fluid injection means. If the pressure of the fluid increases, the force between the sealing structure of the capsule and the free end of the enclosing member increases too and thereby the force between the sealing structure of the capsule and the free end of the enclosing member increases also. Such a system is described further on. The sealing structure of the capsule must be arranged such that upon reaching the maximum fluid pressure in the enclosing member the sealing structure should still provide a fluid sealing contact between the enclosing member and the capsule. However, the sealing structure must also be arranged such that prior to, or at the start of, brewing when the pressure of the fluid in the enclosing member outside the capsule is relatively low, the sealing structure also provides a sealing contact between the enclosing member and the capsule. If at the start of brewing, there would not exist a sealing contact between the capsule and the enclosing member, leakage will occur. However, if leakage occurs there is a real chance that the pressure in the enclosing member and outside the capsule will not sufficiently increase for increasing the force on the sealing structure by means of the free end of the enclosing member if the manually operated or automatic mechanism moves the enclosing member towards the capsule holder. Only if there is a sufficient initial sealing, the pressure in the enclosing member will increase whereby also the force of the free end of the enclosing member acting on the sealing structure of the capsule will increase for providing a sufficient sealing contact at also the increased fluid pressure. Moreover, this increased fluid pressure outside the capsule also provides an increased fluid pressure inside the capsule which is essential if the capsule is provided with a cover which is arranged to tear open on relief members of the capsule holder (also called an extraction plate) of the beverage preparation device under the influence of fluid pressure in the capsule.

SUMMARY

It follows from the above that the sealing structure is a member which is very critical in design. It should be able to provide a sealing contact between the enclosing member and the capsule at a relatively low fluid pressure if only a relatively small force is applied on the sealing structure by means of the free end of the enclosing member but it should also provide a sealing contact at a much higher fluid pressure in the enclosing member outside the capsule if a higher force is applied by means of the free end of the enclosing member to the sealing structure of the capsule. In particular when the annular end surface of the enclosing member is provided with radially extending open grooves which act as air inlet passage once the force between the enclosing member and the capsule holder is released so that it is easier for a user to take out the capsule, the sealing structure must also be able to 'close' the radially extending open grooves to provide an effective seal.

From WO2012/120459, a capsule is known in which the sealing structure includes a deformable portion of the outwardly projecting flange of the capsule body. However, for ensuring that the sealing ring portion provides a sealing contact against the annular end surface of the enclosing member, as it is deformed between that annular surface and the closing member, the annular end surface of the enclosing member has deforming means in the form of a shallow, rounded groove extending in circumferential sense of the annular surface. In operation, the shallow, rounded groove ensures that an upstanding rib of the deformable portion folds over inwardly. Accordingly, reliable functioning of such capsules will be ensured for use in particular beverage preparation devices only.

It is an object of the invention to provide a capsule that reliably seals against the annular end surface of an enclosing member of a beverage preparation device if the capsule is positioned in the enclosing member of the beverage preparation device and the enclosing member is closed by means of a closing member of the beverage preparation device, such as an extraction plate of the beverage preparation device, a portion of the outwardly extending flange of the capsule and the sealing structure of the capsule being clamped between the annular end surface of the enclosing member and the closing member of the beverage preparation device, even in case of an enclosing member of which the annular end surface is provided with radially extending open grooves and which can still be manufacture at low costs and is environmentally friendly and easily recyclable after the capsule has been disposed of after use. In many of the known capsules, the sealing member is made from an elastic material such as rubber elastic material, more specific such as a silicon material which after use, should be separated from the aluminum base and cover for recycling purposes.

This object is achieved by providing a capsule containing a substance for the preparation of a potable beverage by extracting and/or dissolving the substance by means of supplying a fluid under pressure into the capsule.

Because the sealing structure includes a deformable sealing ring portion of the flange, the sealing ring portion projecting axially from base portions of the flange on a side of the base portions opposite of the cover, the sealing structure is integrated in the flange of the capsule, so the capsule can be manufactured quickly at low costs and the aluminum capsule body can be recycled easily. In the present context, the meaning of 'aluminum' is understood to also include aluminum alloy.

Because a top of the bridge portion axially most remote from the base portions of the flange is flat or has a center plane curved with a radius of curvature larger than two times a wall thickness of said top of the bridge portion, the bridge portion is easily deformable locally at low clamping pressure to accommodate to the shape of the annular end surface of the enclosing member when clamped between the annular end surface of the enclosing member and the closing member. Even in case of an enclosing member of which the annular end surface is provided with radially extending open grooves, the sealing structure can accommodate to the succession of projections and recesses in circumferential sense formed by the annular end surface of the enclosing member and effectively seal, also against the recessed surface portions of the annular end surface already during an early stage of the closing of the enclosing member when the clamping pressure at which the enclosing member and the closing member are pressed against each other is relatively low.

It is noted that for the sealing between the annular end surface of the enclosing member and the sealing ring portion of the flange to be effective for ensuring that the pressure drop over the substance in the capsule is sufficient for the desired beverage preparation process, it does not have to be hermetically fluid tight under all circumstances. At a liquid leakage of up to 4% and preferably not beyond 2.5% of the liquid volume pumped through the capsule, the seal is still effective for allowing the beverage preparation apparatus to generate the desired pressure drop over the substance. Accordingly, a sealing allowing such a leakage constitutes an effective sealing.

The invention can also be embodied in a system for preparing a potable beverage from a capsule using a fluid supplied under pressure into the capsule and in a use of such a capsule. In operation of such a system and in such a use, the bridge portion easily deforms locally, thereby accommodating to the shape of the annular end surface of the enclosing member when it is clamped between the annular end surface of the enclosing member and the closing member. More in particular, the sealing structure accommodates to the succession of projections and recesses in circumferential sense formed by the annular end surface of the enclosing member and effectively seals, also against the recessed surface portions of the annular end surface already during an early stage of the closing of the enclosing member, when the clamping pressure at which the enclosing member and the closing member are pressed against each other is relatively low.

A good conformability to the shape of the annular end surface and accordingly a particularly effective and reliable sealing already at low sealing pressure can be achieved if at least a portion of the top of the bridge portion has a reduced wall thickness smaller than a wall thickness of the inner and outer wall portions.

If the capsule body has a coating to at least one side, leaving out the coating in at least the portion of the top of the bridge portion having a reduced wall thickness reduces the risk of the coating being damaged or becoming unstuck during relatively large deformations occurring when the wall thickness is reduced during manufacturing. The coating may also be removed while reducing the wall thickness during manufacturing, for instance if reducing the wall thickness involves removing wall material.

A further enhanced sealing effect can be achieved if the uncoated portion of the bridge portion is on a side of the flange opposite of the cover and has a textured surface. A texture in the surface can further improve the conformability during early stages of clamping, when the sealing pressure is still low, because clamping force is transferred via raised portions of the texture only, so that at the raised portions a higher contact pressure is exerted than would be exerted over a full smooth contact surface.

A particularly improved sealing effect can be achieved if the textured surface includes ridges and valleys extending in circumferential sense of the flange, because early conformation to the shape of the annular end surface is then achieved in generally annular areas or ring sectors extending mainly in circumferential sense.

The invention can also be embodied in a method for manufacturing a capsule starting from a semi-finished deep drawn cup member. The coating is efficiently removed from the portion of the flange of which the wall thickness is to be reduced prior to or during reducing the wall thickness.

A particularly efficient manufacturing of the reduced wall thickness can be achieved if the coating is removed from the portion of the flange of which the wall thickness is to be reduced during a material removal step for removing wall material for reducing the wall thickness.

However, a coating on the top portion of the bridge portion, either the same coating as on the remainder of the outer surface of the capsule body or a coating different from the coating on the remainder of the outer surface of the capsule body, can also improve sealing, for instance by reducing friction between the annular end surface of the enclosing member and a surface portion of the sealing ring portion in contact with the annular end surface, which facilitates accommodation of the sealing ring portion in contact with the annular end surface to the shape of the annular end surface.

If one of the inner and outer wall portions is oriented at a different angle to the base portions of the flange than the other one of the inner and outer wall portions, accurate and reliable deformation of the sealing structure to a predetermined shape during sealing can be achieved. In particular the occurrence of transitions between circumferential portions deforming to different end shapes, entailing an increased risk of leakage, is thereby counteracted.

This effect can be achieved particularly effectively if one of the inner and outer wall portions extends at an oblique angle, preferably of 20-60°, and more preferably 30-50°, relative to a plane of the associated contiguous base portion of the flange and the other one of the inner and outer wall portions extends from the associated contiguous base portion of the flange at a steeper or opposite angle, preferably 60-160°, and more preferably 70-150° relative to a plane of the associated contiguous base portion of the flange.

For a smooth, accurate and reliable deformation to a predetermined shape, it is advantageous if, in cross-sectional view, at least a portion of at least one of the inner and outer wall portions has a curved center plane, in particular if the curved portion of the at least one of the inner and outer wall

portions is contiguous to the curvature of the top of said bridge portion and if, in cross-sectional view, the deformable portion is Ω shaped. Another advantage of an Ω shape is that only a small gap is left between inner and outer base portions of the flange so that a large surface area for adherence of the cover to the flange is left.

For obtaining a high counter pressure during a final stage of deformation of the sealing structure, a support member may be provided between the inner and outer wall portions.

A particularly easy accommodation to the shape of the annular end surface may be achieved if, the top of the bridge portion is positioned for being contacted first by the annular end portion, when the sealing ring portion is clamped between the annular end surface and the closing member of a compatible beverage preparation device.

The top of the bridge portion forms a rounded or flat crest extending circumferentially around the center line of the capsule. By providing that the crest formed by the top of the bridge portion has a diameter of 29-33 mm, more preferably 30.0-31.4 mm and most preferably 30.3-31.0 mm, the top of the bridge portion is located centrally relative to the annular end surface for first contacting a central portion of said annular end surface when the sealing ring portion is clamped between the annular end surface and said closing member of widely used and commercially available beverage preparation devices such as the Citiz, Lattisima, U, Maestria, Pixie, Inissia and Essenza.

The invention is in particular advantageous when in an embodiment of a capsule the capsule is filled with 5-20 grams, preferably 5-10 grams, more preferably 5-7 grams of an extractable product, such as roasted and ground coffee.

In an embodiment of a capsule according to the invention which is in particular easy to manufacture the outer diameter of the outwardly extending flange of the capsule is larger than the diameter of the bottom of the capsule. Preferably, the outer diameter of the outwardly extending flange is approximately 37.1 mm and the diameter of the bottom of the capsule is about 23.3 mm.

The invention is in particular advantageous when in an embodiment of a capsule the thickness of the aluminum capsule body is 20 to 200 micrometer, preferably 100 micrometer.

The invention is in particular advantageous when in an embodiment of a capsule the thickness of the aluminum cover is 15 to 65 micrometer, preferably 30-45 micrometer and more preferably 39 micrometer.

In an embodiment of a capsule according to the invention the thickness of the aluminum cover is smaller than the thickness of the aluminum capsule body.

In a further embodiment of a capsule according to the invention the aluminum cover is arranged to tear open on a closing member of the beverage preparation device, such as an extraction plate of the beverage preparation device under the influence of fluid pressure in the capsule.

In an embodiment of a capsule according to the invention which is in particular easy to manufacture the side wall of the aluminum capsule body has a free end opposite the bottom, the outwardly extending flange extending from said free end of the side wall in a direction at least substantially transverse to the central capsule body axis. Preferably, the outwardly extending flange comprises a curled outer edge, which is beneficial in obtaining for a satisfactory sealing with the annular end surface provided with radially extending open grooves. The radius about the central capsule body axis of an inner edge of the curled outer edge of the outwardly extending flange is preferably at least 32 mm, so that clearance from the annular end surface of the enclosure member is ensured. It is then preferred that the sealing structure is positioned between the free end of the side wall of the aluminum capsule body and an inner edge of the curled outer edge of the outwardly extending flange to obtain a still further satisfactory sealing.

To ensure that the curled outer edge does not interfere with operation of a wide variety of commercially available and future beverage preparation apparatuses, the outwardly extending flange has a largest radial cross-sectional dimension of about 1.2 millimeter.

The invention is in particular beneficial for capsules of which the inner diameter of the free end of the side wall of the aluminum capsule body is about 29.5 mm. The distance between the free end of the side wall of the aluminum capsule body and an outermost edge of the outwardly extending flange can be about 3.8 millimeter. The preferred height of the aluminum capsule body is about 28.4 mm.

In an embodiment of a capsule according to the invention which after use is easier for a user to take out of a beverage preparation device the aluminum capsule body is truncated, wherein preferably the side wall of the aluminum capsule body encloses an angle with a line transverse to the central capsule body axis of about 97.5°.

In an advantageous embodiment of a capsule according to the invention the bottom of the aluminum capsule body has a largest inner diameter of about 23.3 mm. It is preferred that the bottom of the aluminum capsule body is truncated, preferably having a bottom height of about 4.0 mm and that the bottom further has a generally flat central portion opposite the cover having a diameter of about 8.3 mm.

In practically all cases a satisfactory seal can be obtained in an embodiment of a capsule according to the invention in which the height of the sealing structure is at least about 0.1 mm, more preferably at least 0.2 mm and most preferably at least 0.8 mm and at most 3 mm, more preferably at most 2 mm and most preferably at most 1.2 mm.

Regarding the preferred embodiments of the system as mentioned in the dependent claims which relate to the same features as the features of the dependent claims of the capsule reference is made to the above.

The invention is particularly suitable in a system according to the invention wherein, in use, the maximum fluid pressure in the enclosing member of the beverage preparation device is in the range of 6-20 bar, preferably between 12 and 18 bar. Even at such high pressures a satisfactory seal between capsule and beverage preparation device can be obtained.

Preferably the system is arranged such that, in use, during brewing, a free end of the enclosing member of the beverage preparation device exerts a force F**2** on the sealing structure of the capsule to provide a sealing contact between the outwardly extending flange of the capsule and the enclosing member of the beverage preparation device, wherein F is in the range of 500-1500 N preferably in the range of 750-1250 N when the fluid pressure P**2** in the enclosing member of the beverage preparation device outside the capsule is in the range of 6-20 bar, preferably between 12 and 18 bar. In particular the system is arranged such that, in use, prior to or at the start of brewing, a free end of the enclosing member of the beverage preparation device exerts a force F**1** on the sealing structure of the capsule to provide a sealing contact between the outwardly extending flange of the capsule and the enclosing member of the beverage preparation device, wherein F**1** is in the range of 30-150 N preferably 40-150 N, more preferably 50-100 N, when the fluid pressure P**1** in the

enclosing member of the beverage preparation device outside the capsule is in the range of 0.1-4 bar, preferably 0.1-1 bar.

In an embodiment of a system according to the invention wherein the plurality of radially extending open grooves are uniformly spaced relative to each other in tangential direction of the annular end surface of the annular element of the beverage preparation device so that it is easier for a user to take out the capsule while a satisfactory seal between capsule and beverage preparation device can still be provided.

In an advantageous embodiment of a system according to the invention the longest tangential width of each groove (top to top, i.e. equal to the groove to groove pitch) is 0.9-1.1 mm, preferably 0.95 to 1.05 mm, more preferably 0.98 to 1.02 mm, wherein a maximal height of each groove in an axial direction of the enclosing member of the beverage preparation device is 0.01-0.09 mm, preferably 0.03 to 0.07 mm, more preferably 0.045 to 0.055 mm, most preferred 0.05 mm and wherein the number of grooves is 90 to 110, preferably 96. The radial width of the annular end surface at the location of the grooves may for instance be 0.05-0.9 mm, preferably 0.2-0.7 mm and more preferably 0.3-0.55 mm.

The invention is in particular suitable when applied to an embodiment of system according to the invention in which during use when the closing member of the beverage preparation device closes the enclosing member of the beverage preparation device the enclosing member of the beverage preparation device can move relative to the closing member of the beverage preparation device under the effect of the pressure of the fluid in the enclosing member of the beverage preparation device towards the closing member of the beverage preparation device for applying the maximum force between the flange of the capsule and the free end of the enclosing member of the beverage preparation device.

BRIEF DESCRIPTION OF THE DRAWINGS

Further aspects, effects and details of the invention will now be further described with reference to, non-limiting, examples shown in the drawing, in which:

FIG. **1** shows a schematic representation of an embodiment of a system according to the invention;

FIG. **2** in a perspective view shows an embodiment of a beverage preparation device of a system according to the invention showing the annular end surface of the enclosing member of the beverage preparation device with the plurality of radially extending open grooves;

FIG. **3**A in cross section shows an embodiment of a capsule according to the invention before use;

FIG. **3**B shows an enlarged detail of a the capsule of FIG. **3**A showing the outwardly extending flange and the sealing structure;

FIG. **3**C shows an enlarged detail of the outwardly extending flange of the capsule in FIGS. **3**A and **3**B after use;

FIGS. **4**A to **4**H show several embodiments of a sealing structure at the outwardly extending flange of a capsule according to the invention.

DETAILED DESCRIPTION

FIG. **1** shows a schematic representation, in cross sectional view, of an embodiment of a system **1** for preparing a potable beverage from a capsule using a fluid supplied under pressure into the capsule. The system **1** comprises a capsule **2** that is sealed so as to be sealed, and a beverage preparation device **4**. The device **4** comprises enclosing member **6** for holding the capsule **2**. The device **4** further comprises a closing member, such as an extraction plate, **8** for supporting the capsule **2**.

In FIG. **1** a gap is drawn between the capsule **2**, the enclosing member **6** and the extraction plate **8** for clarity. It will be appreciated that, in use, the capsule **2** may lie in contact with the enclosing member **6** and the extraction plate member **8**. Commonly, the enclosing member **6** has a shape complementary to the shape of the capsule **2**. The apparatus **4** further comprises a fluid injection means **10** for supplying an amount of a fluid, such as water, under a pressure in the range of 6-20 bar, preferably between 12 and 18 bar, to the exchangeable capsule **2**.

In the example shown in FIG. **1**, the exchangeable capsule **2** comprises an aluminum capsule body **12** having a central capsule body axis **12**A and an aluminum cover (which may alternatively be referred to herein as a cover sheet) **14**. In this example, the aluminum capsule body **12** comprises a side wall **16**, a bottom **18** closing the side wall **16** at a first end, and a outwardly extending flange **20** extending outwardly of the side wall **16** at a second end opposite the bottom **18**. The side wall **16**, the bottom **18** and the cover **14** enclose an inner space **22** comprising a substance for the preparation of a potable beverage by extracting and/or dissolving the substance. Preferably the substance is 5-20 grams, preferably 5-10 grams, more preferably 5-7 grams of an extractable product, such as roasted and ground coffee for the preparation of a single beverage. The capsule is initially sealed, i.e. is sealed prior to use.

The system **1** of FIG. **1** comprises bottom piercing means **24** for piercing the bottom **18** of the capsule **2** for creating at least one entrance opening **25** in the bottom **18** for supplying the fluid to the extractable product through the entrance opening **25**.

The system **1** of FIG. **1** further comprises cover piercing means **26**, here embodied as protrusions of the closing member **8**, for piercing the cover **14** of the capsule **2**. The cover piercing means **26** may be arranged to tear the cover **14** once a (fluid) pressure inside the inner space **22** exceeds a threshold pressure and presses the cover **14** against the cover piercing means **26** with sufficient force. The aluminum cover **14** thus is arranged to tear open on the closing member **8** of the beverage preparation device under the influence of fluid pressure in the capsule.

The capsule **2** further comprises a sealing structure **28**, in FIGS. **1**, **3**A and **3**B indicated as a general box but more detailed described with reference to FIGS. **4**A-**4**H, which sealing structure **28** is arranged at the outwardly extending flange **20** for providing a fluid sealing contact with the enclosing member **6** if the capsule **2** is positioned in the enclosing member **6** and the enclosing member **6** is closed by means of the extraction plate **8**, such that the outwardly extending flange **20** of the capsule **2** and at least a portion of the sealing structure **28** are sealingly engaged between the enclosing member **6** and the extraction plate **8**.

As shown in FIG. **2** the enclosing member **6** of the beverage preparation device comprises an annular element **41** having a central annular element axis **41**A and a free annular end surface **30**. The free annular end surface **30** of the annular element **41** is provided with a plurality of radially extending open grooves **40**. The plurality of radially extending open grooves **40** are uniformly spaced relative to each other in tangential direction of the free annular end surface **30** of the annular element **41**. The longest tangential width of each groove **40** is 0.9-1.1 mm, preferably 0.95 to 1.05 mm, more preferably 0.98 to 1.02 mm, wherein a

maximal height of each groove **40** in an axial direction of the enclosing member **6** is 0.01-0.09 mm, preferably 0.03 to 0.07 mm, more preferably 0.045 to 0.055 mm, and most preferred 0.05 mm. The number of grooves **40** lies in the range of 90 to 110, preferably 96. The radial width of the annular end surface at the location of the grooves may for instance be 0.05-0.9 mm, preferably 0.2-0.7 mm and more preferably 0.3-0.55 mm.

An embodiment of a capsule according to the invention is shown more detailed in FIGS. **3**A and **3**B. In the shown embodiment the outer diameter ODF of the outwardly extending flange **20** is larger than the diameter DB of the bottom **18** of the capsule **2**. In the shown embodiment the outer diameter ODF of the outwardly extending flange **20** is approximately 37.1 mm and the diameter DB of the bottom **18** is about 23.3 mm. In the present example, the wall thickness of the aluminum capsule body **12** is 100 micrometer. Generally, a wall thickness of, depending on various considerations, 20 to 200 micrometer is preferred.

In the shown embodiment the thickness of the aluminum cover **14** is 39 micrometer, preferred thickness ranging from 15-65 micrometer and more in particular 30-45 micrometer. Preferably the thickness of the aluminum cover **14** is smaller than the thickness of the aluminum capsule body **12**.

The side wall **16** of the aluminum capsule body **12** has a free end **42** opposite the bottom **18**. The inner diameter IDF of the free end **42** of the side wall **16** of the aluminum capsule body **12** is about 29.5 mm. The outwardly extending flange **20** extends from that free end **42** in a direction at least substantially transverse to the central capsule body axis **12**A. The outwardly extending flange **20** comprises a curled outer edge **43** which is beneficial for obtaining a seal between the capsule and the enclosing member. In the shown embodiment the curled outer edge **43** of the outwardly extending flange **20** has a largest dimension of about 1.2 millimeter. The distance DIF between the free end **42** of the side wall **16** of the aluminum capsule body **12** and an inner edge **43**A of the curled outer edge **43** is about 2.7 mm, while the distance DOF between the free end **42** of the side wall **16** of the aluminum capsule body **12** and an outermost edge **43**B of the outwardly extending flange **20** is about 3.8 millimeter.

As shown in FIGS. **3**A and **3**B the sealing structure **28** is positioned between the free end of the side wall **16** of the aluminum capsule body **12** and the inner edge **43**A of the curled outer edge **43** of the outwardly extending flange. The sealing structure **28** is indicated as a general box, but will be described in more detail below. Irrespective of the embodiment of the sealing structure **28** the height of the sealing structure is preferably at least about 0.1 mm, more preferably at least 0.2 mm and most preferably at least 0.8 mm and at most 3 mm, more preferably at most 2 mm and most preferably at most 1.2 mm for providing a correct seal.

As can be seen from FIG. **3**A the aluminum capsule body **12** is truncated. In the embodiment shown, the side wall **16** of the aluminum capsule body **12** encloses an angle A with a line transverse to the central capsule body axis **12**A of about 97.5°. The bottom **18** of the aluminum capsule body **12** has a largest inner diameter DB of about 23.3 mm. The bottom **18** of the aluminum capsule body **12** is also truncated, and in the shown embodiment has a bottom height BH of about 4.0 mm. The bottom **18** further has a generally flat central portion **18**A opposite the cover **14**, which central portion **18**A has a diameter DEE of about 8.3 mm and in which central portion **18**A the entrance opening(s) **25** may be made. The entrance openings may also be made in the truncated portion between the central portion **18**A and the side wall **16**. The total height TH of the aluminum capsule body **12** of the capsule is about 28.4 mm.

The system **1** shown in FIG. **1** is operated as follows for preparing a cup of a potable beverage, in the present example coffee the substance in the capsule being roasted and ground coffee.

The capsule **2** is placed in the enclosing member **6**. The extraction plate **8** is brought into contact with the capsule **2**. The bottom piercing means **24** pierce the bottom **18** of the capsule **2** for creating the entrance openings **25**. The fluid, here hot water under pressure, is supplied to the extractable product in the inner space **22** through the entrance openings **25**. The water will wet the coffee grounds and extract the desired substances to form the coffee beverage.

During supplying the water under pressure to the inner space **22**, the pressure inside the capsule **2** will rise. The rise in pressure will cause the cover **14** to deform and be pressed against the lid piercing means **26** of the extraction plate. Once the pressure reaches a certain level, the tear strength of the cover **14** will be surpassed and the cover **14** will rupture against the lid piercing means **26**, creating exit openings. The prepared coffee will drain from the capsule **2** through the exit openings and outlets **32** (see FIG. **1**) of the extraction plate **8**, and may be supplied to a container such as a cup (not shown).

The system **1** is arranged such that prior to or at the start of brewing, the free annular end surface **30** of the enclosing member **6** exerts a force F**1** on the sealing structure **28** of the capsule **2** to provide a sealing contact between the outwardly extending flange **20** of the capsule **2** and the enclosing member **6** of the beverage preparation device, wherein the force F**1** is in the range of 30-150 N, preferably 40-150 N and more preferably 50-100N, when the fluid pressure P**1** in the enclosing member of the beverage preparation device outside the capsule is in the range of 0.1-4 bar, preferably 0.1-1 bar. During brewing, the free annular end surface **30** of the enclosing member **6** exerts a force F**2** on the sealing structure **28** of the capsule **2** to provide a sealing contact between the outwardly extending flange **20** of the capsule **2** and the enclosing member **6**, wherein the force F**2** is in the range of 500-1500 N, preferably in the range of 750-1250 N, when the fluid pressure P**2** in the enclosing member **6** of the beverage preparation device outside the capsule **2** is in the range of 6-20 bar, preferably between 12 and 18 bar. In the shown embodiment a part **6**B of the enclosing member **6** can move relative to the extracting plate **8** under the effect of the pressure of the fluid in the enclosing member **6** device towards the extraction plate **8** for applying the maximum force between the outwardly extending flange **20** and the free annular end surface **30** of the enclosing member **6**. This movement can take place during use, i.e. at the start of brewing and during brewing. The enclosing member **6** has a first part **6**A and a second part **6**B wherein the second part comprises the free annular end surface **30**. The second part **6**B can move relative to the first part **6**A between a first and second position. The second part **6**B can move from the first position towards the second position in the direction of the closing member **8** under the influence of fluid pressure in the enclosing member **6**. The force F**1** as discussed above may be reached if the second part **6**B is in the first position with a fluid pressure P**1**. The force F**2** as discussed above may be reached if the second part **6**B is moved towards the second position under the influence of the fluid pressure P**2** in the enclosing member **6**.

As a result of the force applied the sealing structure **28** of the capsule according to the invention undergoes a plastic deformation and closely conforms to the grooves **40** of the

free annular end surface **30** and thus provides a sealing contact between the enclosing member **6** and the capsule **3** at a relatively low fluid pressure during start up of brewing but also provides a sealing contact at the much higher fluid pressure in the enclosing member outside the capsule during brewing. This close conformation to the grooves **40** of the enclosing member is indicated in FIG. **3**C which shows the capsule **2** of the invention after use, and which clearly indicates that the outwardly extending flange **20** comprises deformations **40'** which conform to the grooves **40** of the enclosing member.

Now exemplary embodiments of a sealing structure **28** at the outwardly extending flange **20** of the capsule **2** according to the invention will be described in more detail with regard to FIGS. **4**A to **4**H.

In FIG. **4**A, a first example of flange **20** with a sealing structure **28** in contact with an annular end surface of an enclosing member **6** prior to deformation of the sealing structure **28** is shown. The sealing structure **28** is in the form of a deformable sealing ring portion **128** of the flange **20**. The cover **14** is attached to base portions **44**, **45** of the flange **20**, which define a flat base level plane of the flange **20** perpendicular to the capsule body axis. The sealing ring portion **128** projects axially from the base portions **44**, **45** of the flange **20** on a side of the base portions **44**, **45** opposite of the cover **14** (i.e. the side facing the free annular end surface **30**).

The deformable sealing ring portion **128** has an inner wall portion **46** extending from and contiguous with an inner base portion **44** of the flange **20** and an outer wall portion **47** extending from and contiguous with an outer base portion **45** of the flange **20**. The outer wall portion **47** is located outward of and spaced from the inner wall portion **46**. The deformable sealing ring portion **128** further includes a bridge portion **48** interconnecting the inner wall portion **46** and the outer wall portion **47**. The bridge portion **48** is located axially spaced from the base portions **44**, **45** of the flange **20**.

In the cross-sectional view as shown, a top **49** of the bridge portion axially most remote from the base portions of the flange **44**, **45** has a center plane curved with a radius of curvature larger than two times the wall thickness of the top **49** of the bridge portion **48**. Because the radius of curvature is relatively large, it can be deformed relatively easily to accommodate to the shape of the free annular end surface **30** as the free annular end surface **30** is pressed against the deformable sealing ring portion **128** causing it to be deformed. Since the deformable sealing ring portion **128** is an integral portion of the capsule body, it can be manufactured efficiently and, being of the same material as the rest of the capsule body, it can be recycled together with the rest of the capsule body after use and disposal of the capsule.

The inner wall portion **46** is oriented at a different angle to the base portions of the flange **44**, **45** than the outer wall portion **47**. This results in accurate and reliable deformation of the sealing structure **28** to a predetermined shape during sealing. In particular, it is avoided that transitions between circumferential sections deforming to different end shapes are formed during deformations. Such transitions entail an increased risk of leakage.

In the present example, this effect is achieved particularly effectively because the outer wall portion **47** extends at an oblique angle A_{ob} relative to a plane of the associated contiguous base portion of the flange **45** and the inner wall portion **46** extends from the associated contiguous base portion of the flange **44** at an acute angle A_{ac} and opposite angle A_{opp}, so that it is parallel to the outer wall portion **47**. The oblique angle A_{ob} and the acute angle A_{ac} is each preferably 20-60°, and more preferably 30-50°, and the opposite angle A_{opp} is preferably 120-160°, and more preferably 110-150° relative to a plane of the respective, associated contiguous base portions of the flange **44**, **45**.

In the example shown in FIG. **4**B, the outer wall portion **147** is about perpendicular the base portion of the flange contiguous therewith. In addition to a curved portion including the top portion **149**, the bridge portion **148** also has an oblique, generally flat portion **150**. For a smooth, accurate and reliable deformation to a predetermined shape, the inner wall portions **146** has a curved center plane contiguous to the curvature of the top of said bridge portion. The relatively easy compressibility of the curved inner wall portion **146** is accommodated by a generally hinging deflection of the flat portion **150** of the bridge portion about its connection to the outer wall portion **147**. Thus, it is avoided that the inner wall portion **146** and an adjacent portion of the bridge portion **148** are folded flat to one side and ensured that the curved sections formed by these portions is folded onto itself during deformation, thereby ensuring that during deformation a relatively constant counterforce is exerted.

In FIG. **4**C, an example is shown in which the top **249** of the bridge portion **248** is flat (i.e. has an infinitely large radius of curvature). Also, such a flat wall portion is deformable relatively easily for smooth accommodation to the shape of the free annular end surface **30**. The inner and outer wall portions **246**, **247** are oriented perpendicularly to the adjacent base portions of the flange **244**, **245**, so that a particularly stiff support of the bridge portion **248** is obtained, which prevents the bridge portion from being displaced as a whole as a result of the pressure exerted by the free annular end surface **30**, so deformations are, at least initially, concentrated in the bridge portion **248** itself. In turn, this is advantageous for accommodation of the shape of the sealing ring portion **228** to the shape of the free annular end surface **30**. A particularly effective and reliable sealing already at low sealing pressure can be achieved if at least a portion of the top **249** of the bridge portion **248** has a reduced wall thickness smaller than a wall thickness of the inner and outer wall portions **247**, **246** (the reduced wall thickness is not shown in FIG. **4**C). In this and other embodiments, the reduced thickness may of at least the top portion of the bridge portion may for instance be 10-95 micrometer, more preferably 30-70 micrometer, most preferably 40-50 micrometer.

In the example shown in FIG. **4**D, the deformable sealing ring portion **328** is Ω shaped, the inner wall portion **346**, the bridge portion **348** with top **349** and the outer wall portion **347** having an essentially constant radius of curvature. Such a shape is particularly advantageous for a smooth, accurate and reliable deformation to a predetermined shape. Another advantage of such a shape is that only a small gap is left between inner and outer base portions of the flange **344**, **345** so that a large surface area for adherence of the cover (also referred to herein as cover sheet) **14** to the flange is left.

Also in the example shown in FIG. **4**E, the deformable sealing ring portion **428** is Ω shaped, but has a larger radius of curvature, such that the width of the Ω shaped portion is at least as wide as the width of the free annular end surface **30**. This allows the annular end surface to be pressed into the (originally) Ω shaped portion, of which the width increases during deformation, so that a particularly effective double sealing is achieved at outer and inner border areas of free annular end surface **30**.

In the example shown in FIG. **4**F, a support member **551** of a relatively resilient material is provided between the inner and outer wall portions **546**, **547** and under the bridge

portion **548** for obtaining a high counter pressure during a final stage of deformation of the sealing structure. Such a support member is particularly advantageous if, as in the present example, the deformable sealing ring portion **528** is of a relatively flat configuration.

A particularly good conformability to the shape of the free annular end surface **30** and accordingly a particularly effective and reliable sealing already at low sealing pressure can be achieved if, as in the example shown in FIG. **4**G, at least a portion of the top **649** of the bridge portion **648** has a reduced wall thickness smaller than a wall thickness of the inner and outer wall portions **647**, **646**.

The bridge portion **649** may have an uncoated surface facing the free annular end surface **30** whereas the rest of the capsule body material may be coated on the same side or on both sides, to avoid damage to the coating during reduction of the wall thickness or by removing the coating while reducing the wall thickness. While the coating is removed, a texture may be applied to the surface from which the coating is removed, forming a textured surface **649**A. Such a texture, preferably including ridges and valleys in circumferential sense of the flange, can further improve the conformability during early stages of clamping, when the sealing pressure is still low, because clamping force is transferred via raised portions of the texture only, so that at the raised portions a higher contact pressure is exerted than would be exerted over a full smooth contact surface.

In FIG. **4**H, an example is shown in which one of the wall portions **746**, **747** (in this case the outer wall portion **747**) is oriented more steeply relative to the base portions of the flange **744**, **745** than the other one of the wall portions **746**, **747** (in this case the inner wall portion **746**), which is oriented obliquely relative to the base portions of the flange **744**, **745**. Also in this example, the oblique inner wall portion **746**, which pivots as it follows deformation of the bridge portion **748** and of the steep outer wall portion **747**, prevents the steep outer wall portion **747** that is deformed most from folding over. The steep outer wall portion **747** is positioned, such that it is deflected to the outside of the free annular end surface **30** as the enclosing member is pushed against the top portion **749** of the bridge portion. The wall material of a top end of the steep outer wall portion **747** is then deformed in a rolling off fashion as it follows the bridge portion **748** that is pushed down and radially held by the pivoting inner wall portion **746**, as is illustrated by the deformed conditions **728'** and **728"** of the deformable sealing portion **728** shown in FIG. **4**H. Thus, initially a local deformation accommodating to the shape of the free annular end surface **30** is achieved when the free annular end surface **30** is pressed against the top portion **749** of the bridge portion **748**. Subsequently, the deformation in a rolling off fashion allows smooth axial deformation over a large trajectory.

In each of the examples shown in FIG. **4**A-**4**H, the top of the bridge portion is positioned for being contacted first by the free annular end surface **30**, when the sealing ring portion is clamped between the annular end surface and the closing member of a compatible beverage preparation device. The diameter of the top of the bridge portion is moreover such that the top of the bridge portion is located centrally relative to the free annular end surface **30** for first contacting a central portion of that annular end surface when the sealing ring portion is clamped between the annular end surface and said closing member of a compatible beverage preparation device.

In the foregoing specification, the invention has been described with reference to specific examples of embodiments of the invention. It will, however, be evident that various modifications and changes may be made therein without departing from the broader spirit and scope of the invention as set forth in the appended claims.

The invention claimed is:

1. A capsule containing a substance for the preparation of a potable beverage by extracting and/or dissolving the substance by supplying a fluid under pressure into the capsule, said capsule comprising:

an aluminum capsule body having a central capsule body axis, said aluminum capsule body comprising a bottom, a side wall, an outwardly extending flange and a sealing structure at said outwardly extending flange; and

a cover sheet attached to said outwardly extending flange and hermetically closing off the capsule;

wherein said sealing structure is deformable for providing a fluid sealing contact with an annular end surface of an enclosing member of a beverage preparation device when the capsule is positioned in said enclosing member and said enclosing member is closed by a closing member of the beverage preparation device, at least portions of said outwardly extending flange and said sealing structure is clamped between said annular end surface and said closing member;

wherein said sealing structure includes a deformable sealing ring portion of said outwardly extending flange, said sealing ring portion projecting axially from base portions of said outwardly extending flange, to which said cover sheet is attached, on a side of said base portions opposite of said cover sheet, said deformable sealing ring portion comprising:

an inner wall portion extending from and contiguous with an inner base portion of said outwardly extending flange;

an outer wall portion extending from and contiguous with an outer base portion of said outwardly extending flange, said outer wall portion is located radially outward of and radially spaced from said inner wall portion;

a bridge portion interconnecting said inner wall portion and said outer wall portion, said bridge portion is located axially spaced from said base portions of said outwardly extending flange;

wherein, in radial cross-sectional view, a top of said bridge portion axially most remote from said base portions of the outwardly extending flange is curved with a radius of a curvature larger than two times a wall thickness of said top of said bridge portion, wherein at least a portion of the top of said bridge portion has a reduced wall thickness smaller than a wall thickness of said inner and outer wall portions, wherein said outer wall portion extends at an oblique angle relative to a plane of the associated contiguous outer base portion of the outwardly extending flange and said inner wall portion extends from the associated contiguous inner base portion of the outwardly extending flange at a steeper or opposite angle relative to the plane of the associated contiguous inner base portion of the outwardly extending flange, and wherein, in cross-sectional view, at least a portion of said inner wall portion is a curved portion and said curved portion of said inner wall portion is contiguous to the curvature of said top of said bridge portion, the inner wall portion is undercut by the associated contiguous inner base portion of the outwardly extending flange and at least a part of the inner wall portion is oriented at an acute angle

relative to the contiguous inner base portion of the outwardly extending flange and overhangs the contiguous inner base portion of the outwardly extending flange, and the curved portion of the inner wall portion and the contiguous inner base portion of the outwardly extending flange is folded onto itself during deformation; and a coating to at least one side of said aluminum capsule body, wherein said coating is absent in at least said portion of the top of said bridge portion having a reduced wall thickness, wherein said portion of the top of said bridge portion where the coating is absent is on a side of said outwardly extending flange opposite of said cover sheet and has a textured surface.

2. The capsule according to claim **1**, wherein said textured surface includes ridges and valleys extending in circumferential sense of said outwardly extending flange.

3. The capsule according to claim **1**, wherein said outer wall portion extends at an oblique angle of 20-60° relative to a plane of the associated contiguous base portion of the outwardly extending flange and said inner wall portion extends from the associated contiguous base portion of the outwardly extending flange at an angle of 60-160° relative to said plane of the associated contiguous base portion of the outwardly extending flange.

4. The capsule according to claim **1**, wherein, in cross-sectional view, at least a portion of said outer wall portion has a curved center plane.

5. The capsule according to claim **4**, wherein said curved portion of said outer wall portion is contiguous to the curvature of said top of said bridge portion.

6. The capsule according to claim **5**, wherein, in cross-sectional view said deformable sealing ring portion is Ω shaped.

7. The capsule according to claim **1**, further comprising a support member between said inner and outer wall portions.

8. The capsule according to claim **1**, wherein said top of said bridge portion is contacted first by said annular end surface, when said sealing ring portion is clamped between said annular end surface and said closing member of a compatible beverage preparation device.

9. The capsule according to claim **8**, wherein said top of said bridge portion forms a crest extending circumferentially about the center line of the capsule, said crest having a diameter of 29-33 mm.

10. The capsule according to claim **1**, wherein the capsule is filled with 5-20 grams.

11. The capsule according to claim **1**, wherein the outer diameter of the outwardly extending flange of the capsule is larger than the diameter of the bottom of the capsule.

12. The capsule according to claim **11**, wherein the outer diameter of the outwardly extending flange is 37.1 mm and the diameter of the bottom of the capsule is 23.3 mm.

13. The capsule according to claim **1**, wherein the thickness of the aluminum capsule body is 20 to 200 micrometer.

14. The capsule according to claim **1**, wherein the cover sheet is of aluminum having a thickness of 15 to 65 micrometer.

15. The capsule according to claim **1**, wherein the aluminum capsule body has a wall thickness larger than the wall thickness of the cover sheet.

16. The capsule according to claim **1**, wherein the cover sheet is arranged to tear open on the closing member of the beverage preparation device under the influence of fluid pressure in the capsule.

17. The capsule according to claim **1**, wherein the side wall of the aluminum capsule body has a free end opposite the bottom, the outwardly extending flange extending from said free end of the side wall in a direction transverse to the central capsule body axis.

18. The capsule according to claim **15**, wherein the outwardly extending flange comprises a curled outer edge radially outside of said sealing portion.

19. The capsule according to claim **18**, wherein an inner edge of the curled outer edge of the outwardly extending flange has a radius about the central capsule body axis of at least 32 mm.

20. The capsule according to claim **18**, wherein the curled outer edge of the outwardly extending flange has a largest radial cross-sectional dimension of 1.2 millimeter.

21. The capsule according to claim **17**, wherein the inner diameter of the free end of the side wall of the aluminum capsule body is 29.5 mm.

22. The capsule according to claim **5**, wherein the distance between the free end of the side wall of the aluminum capsule body and an outermost edge of the outwardly extending flange is 3.8 millimeter.

23. The capsule according to claim **1**, wherein the aluminum capsule body has a height in axial direction of 28.4 mm.

24. The capsule according to claim **1**, wherein the aluminum capsule body is truncated, wherein the side wall of the aluminum capsule body encloses an angle with a line transverse to the central capsule body axis of 97.5°.

25. The capsule according to claim **1**, wherein the bottom of the aluminum capsule body has a largest inner diameter of 23.3 mm.

26. The capsule according to claim **25**, wherein the bottom of the aluminum capsule body is truncated and has a bottom height of 4.0 mm and wherein the bottom further has a flat central portion opposite the cover sheet having a diameter of 8.3 mm.

27. The capsule according to claim **1**, wherein the sealing structure has a height in axial direction of at least 0.1 mm.

28. The capsule according to claim **1**, wherein the sealing ring portion is deformable and effectively seals against the annular end surface when during brewing, said annular end surface exerts a force F on the sealing structure of the capsule to provide a sealing contact between said outwardly extending flange and said annular end surface, wherein F is in the range of 500-1500 N when the fluid pressure in said enclosing member outside the capsule is in the range of 6-20 bar.

29. The capsule according to claim **1**, wherein the sealing ring portion is deformable and effectively seals against the annular surface when, in use, prior to or at the start of brewing, said annular end surface exerts a force F1 on the sealing structure of the capsule to provide a sealing contact between said outwardly extending flange and said annular end surface, wherein the force F1 is in the range of 30-150 N when the fluid pressure P1 in the enclosing member of the beverage preparation device outside the capsule is in the range of 0.1-4 bar.

30. The capsule according to claim **1**, wherein the sealing ring portion is deformable and effectively seals against the annular surface when the annular end surface that is pressed against the sealing ring portion has a plurality of radially extending open grooves uniformly spaced relative to each other in circumferential sense of said annular end surface.

31. The capsule according to claim **30**, wherein the sealing ring portion is deformable and effectively seals against the annular surface when the greatest width of each of said grooves is 0.9 - 1.1 mm, wherein a maximal height of each of said grooves in an axial direction of the enclosing member of the beverage preparation device is 0.01 - 0.09

mm, and wherein the number of said grooves is 90 to 110, and wherein the radial width of the annular end surface at the location of the grooves is 0.05- 0.9 mm.

32. The capsule according to claim **1**, wherein the sealing ring portion and the remainder of the aluminum capsule body are made of the same plate material.

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